A NEW FLOATING EVAPORIMETER

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By

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Abstract

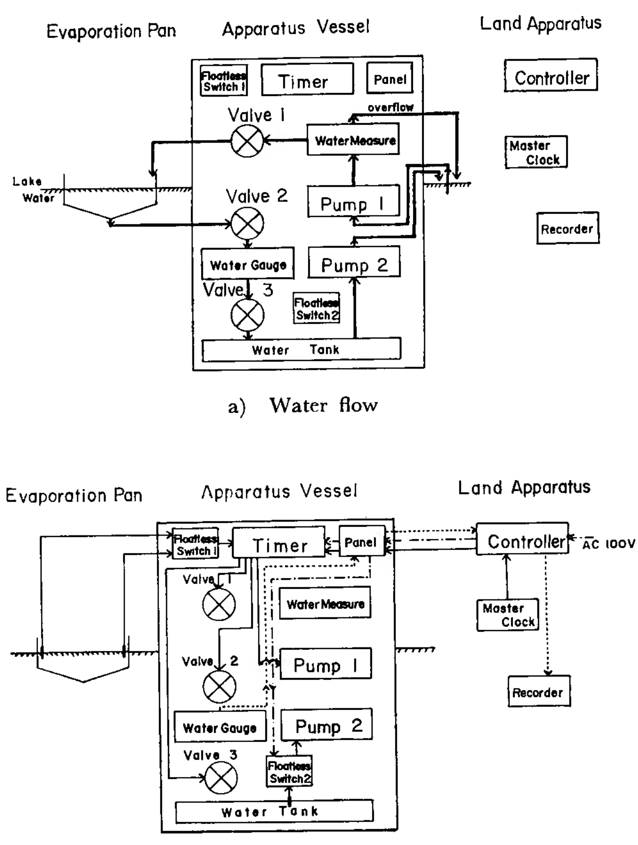
A new evaporimeter for overwater measurement has been developed, which uses volume decrease of water in the pan to measure evaporation rate. The whole water in the evaporation pan is turned out and its volume decrease is measured on the raft every six hours. The operation of the instrument is entirely automatic. The evaporation rate is measured to 1/10 mm, even the pan is swaying, and is recorded on the coast by electric means. The instrument was tested at a small reservoir and the results was satisfactory.

1. Introduction

The measurement of water loss by evaporation from tanks and pans has occupied a central position in empirical studies of evaporation. The study of evaporation from open free water surfaces, which is particularly important in the investigation and calculation of a water budget of lakes and artificial reservoirs, should be pursued by the use of floating installations. But to install the commonly used evaporation pan on the raft is generally unsatisfactory because most of them are of water-depth type and their readings produce great errors if the raft is swayed by waves or slanted. A new type floating evaporimeter is developed by the present author to get free from this difficulty. It is of water-volume measurement type and its indication can be recorded automatically on the coast by electric means, which saves the prodigious labor to go to the raft by a boat and to read the evaporimeter everyday.

2. Principle of operation

The principle of operation of this new evaporimeter and the function of the major parts are shown in Fig. 1. The timer is started by the six hourly time pulse or the extraordinary start pulse generated when the water level in the pan increases greatly from rain. When started, the timer makes one revolution operating one cycle of measurement shown in Table 1. The evaporation pan is filled with a definite volume of water from the water-measure at first, and six hours later the water is poured into the water-gauge where the volume decrease of the water from the original volume by evaporation in this time interval is detected and is transduced into electrical



a) Water flow

b) Electric circuit

Fig. 1. Block diagram of the new evaporimeter.

Table 1. One cycle of measurement operation conducted by the timer every six hours or in case of extraordinary water level rise of 10 mm from rain

Time (after start)	Operation	Note
0 min.	Holding switch; on	The timer starts.
1-12	Valve 2; open	The water in the pan flows into the water-gauge and its volume is measured.
6-10	Pump 1; on	Lake water is pumped up into the water-measure and the excess water overflows.
16-28	Valve 1; open	The definite volume of water in the water-measure is poured into the pan.
17-29	Valve 3; open	The water in the water-gauge is discharged into the tank and pumped out into the tank and pumped out into the lake by the Pump 2.
30	Holding switch; off	The end of cycle.

signal whose potential is proportional to water volume (level) changes, which is recorded on the land apparatus. And then next definite volume of water is poured into the pan and next observation is begun. This is one cycle of measurement.

The amount of evaporation is generally less than a few millimeters in six hours and to detect and record this water depth decrease on the swaying raft is very difficult and it is almost impossible to measure it to 1/10 millimeters which is minimum requirement in evaporation studies, while the total water loss from the evaporation pan of 2,000 cm^2 in area reaches nearly a half liter in volume per six hours which is enough large to detect by water-guage within the required error limit. But to make the whole cycle automatically on the small raft the total amount of water in the pan is restricted and the area of 2,000 cm^2 is adopted in this instrument which is a little smaller than normal type GGI-3,000 evaporimeter of USSR with 3,000 cm^2 pan (Proskurjakov, et al., [1962]).

3. Instrument design

The whole instrument consists of four parts, they are the evaporation pan, the apparatus vessel, the raft and the land apparatus for recording and controlling. The former two are fixed to the raft floating on the lake, which is fixed by anchors and is connected with ground apparatus by the cables.

The evaporation pan is a cylindrical container with coneshaped base. The inner diameter is 50.5 cm, cross sectional area being 2,000 cm^2. The standard water level in the pan is the same as that of the lake, and central water depth of the pan is about 15 cm. The edge of the pan is 6 cm high from the water surface. Two floatless switches are placed on the side wall of the pan which send the extraordinary starting pulse to the timer when both of them make circuit, water level in the pan rising by 10 mm from the standard level. They are placed on the opposite side to prevent misstarting caused by swaying of the raft. The raft is a framework of 3 m square which is floating on four drum cans at each corner and is covered with underwater protecting net. The pan and the raft are shown in Figs. 2 and 3.

The apparatus vessel is a cylindrical container which is 60 cm in diameter and 170 cm in height, and about two thirds of it is sunk in the water by ballast weight as shown in Fig. 3. In this vessel automatic measurement apparatus are built in. They are shown in Fig. 4. Two pumps are small well pumps for home use. Three valves are magnetic valves operated by normal surpply (AC 100 V). The water-measure has a overflow at the top which discharges the excess water pumped up by Pump 1 in 4 minutes. The total volume of this measure is adjusted in order to coincide with the initial water level in the pan to the standard level (ca 16 liters). The water-guage has a float chamber at the top whose cross section is 200 cm^2 in area.

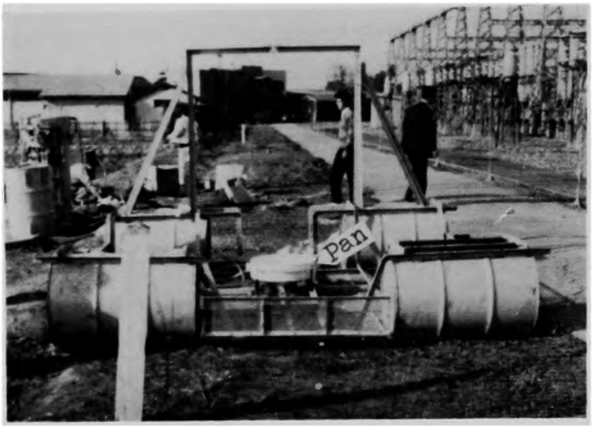


Fig. 2. The pan and the raft.

Fig. 3 The pan and the apparatus vessel on the side of the raft.

Fig. 4. The apparatus in the apparatus vessel.

The float stroke is restricted to 6 cm downward and 14 cm upward from non-evaporation water level in the water-guage, which corresponds to 6 mm of evaporation and 14 mm of rainfall in the pan. The movement of the float is transduced into the rotation of a potentiometer which is detected on the coast. The timer consists of a series of micro-switches operated by coaxial cams driven by a syncronous motor. The waste water tank is at the bottom of the vessel and water is pumped out to the lake by Pump 2 when the water level rises to the limit of Floatless Switch 2. The whole operation can be checked on the panel at the top of the vessel shown in Fig. 4.

The ground apparatus is consists of three parts, they are the controller, the clock and the recorder. The controller supplies electric power and starting pulse to the lake apparatus, and detects the position of the potentiometer of the water-gauge and sends output signal to the recorder. The clock sends a time signal to the controller every six hours. This time interval can easily be changed in this clock. The recorder is a six channel millivolt recorder which is capable to record other meteorological elements such as rainfull, water temperature, dry and wet bulb air temperatures and so on. The non-evaporation point on the record is 3/10 point of full scale and 6 mm of evaporation coinsides to zero point and 14 mm of rainfall to full scale. A schematic example of the record is shown in Fig. 5.

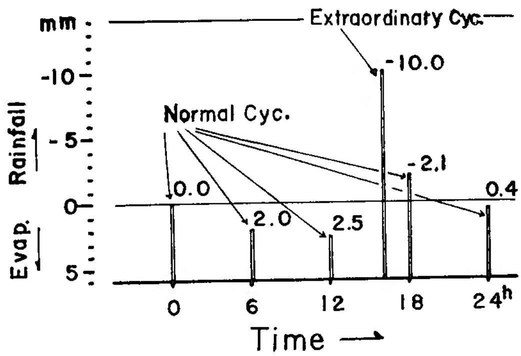


Fig. 5. A schematic example of the record.

4. Field test

This new evaporimeter was tested at a small reservoir of about 10,000 m^2 in area in the suburbs of Osaka from April to October in 1964. The results were satisfactory except some troubles appeared in the beginnings of the period. Fig. 6 shows the evaporimeter at this test site. An example of data obtained is shown in Table 2. In this table, the values with asterisk mean that it rained within the observing period but the amount is less than 0.1 mm and the letter "rain" stands for the case with rainfall more than 0.1mm. The mean evaporation in this period except rainy days is 5.90

Table 2. Evaporation from open free water surface observed by the new floating evaporimeter, in millimeters
(At an artificial reservoir in Kadoma City, Osaka)

May '64	00-06h	06-12h	12-18h	18-24h	Total	Weather
1	1.1*	0.7*	rain	rain	rain	rainy
2	rain	0.6	1.4	0.6	rain	rn. later cl.
3	0.4*	1.0	1.0	0.6	3.0*	cloudy
4	0.5	0.9	1.9	0.7	4.0	cloudy
5	0.9*	rain	rain	0.3*	rain	rainy
6	0.3	0.7	1.2	0.6	2.8	cloudy
7	0.6	1.4	2.3	0.8	5.1	fine
8	0.8	1.7	2.8	1.8	6.3	fine
9	1.1	1.7	2.4	0.9	6.1	fine
10	0.8	1.3	1.9	rain	rain	cl. later rn.
11	rain	1.0	2.3	1.2	rain	rn. later cl.
12	0.6	1.7	3.0	1.4	6.7	fine
13	1.3	1.6	2.8	1.5	7.2	fine
14	1.0	1.6	2.3	1.0	5.9	fn. later cl.
15	0.7	1.5	1.5	1.4	5.1	fine
16	1.1	1.8	2.7	1.1	6.7	fine
17	1.8	1.4	2.4	0.8	6.4	fine
18	0.8	1.1	1.5	0.7	4.1	cloudy
19	1.0	1.8	3.0	1.0	6.8	fine
20	0.8	1.6	3.1	1.0	6.5	fine
21	1.0	1.8	2.3	1.0	6.1	fine
22	1.1	1.8	2.7	0.1*	5.7*	fn. later cl.
23	0.7*	1.5	2.5	1.2	5.9*	cloudy
24	0.7	1.6*	1.9*	rain	rain	cl. later rn.
25	rain	2.2	3.5	1.6	rain	cl. later fn.
26	1.0	2.4	4.3	1.6	9.3	fine
27	1.0	1.9	2.4	1.1	6.4	fine
28	1.0	1.8	2.6	1.0*	6.4*	cloudy
29	0.3*	1.7	2.3*	1.2	5.5*	fn. later cl.
30	0.9	2.0	3.4*	1.5	7.8*	cloudy
Mean exc. rainy days	0.86	1.58	2.46	1.01	5.90	

Note; * : rainfall less than 0.1 mm
rain: rainfall 0.1 mm and over

Fig. 6. The new evaporimeter on the reservoir.

mm in one day and nearly a half of the amount is lossed in the period of 1,200 to 1,800. The detail of this observation and the comparison with the results of other methods of evaporation measurements will be reported in another papers.

5. Conclusions

This paper describes an floating evaporimeter which uses volume decrease of water in the pan in the observation period to measure evaporation rate. Operation of the instrument is entirely automatic and the evaporation rate is measured to 1/10 mm even when the pan is swaying by the waves and is remotely recorded on the coast. Water budget in the pan can be measured even in the heavy rain.

This instrument should provide a reliable index of evaporation from lakes or reservoirs because of its excellent accuracy and convenience in overwater measurements.

Acknowledgements

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Reference

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